The South African government auction mechanism:

Inference from cross-country analysis

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Abstract

Idiosyncratic considerations relevant to South Africa's economic and legal framework, as well as determining factors taken from the financial markets and the asset being auctioned are used to critically review the current auction mechanism used by the South African government to borrow funds publicly. A logistic regression with panel data is used in the empirical analysis. The dependent variable has a dichotomous outcome of uniform-price and discriminatory auction mechanisms. Data from 43 different countries over the period 2005 to 2011 are used for the analysis. It was hypothesized that countries with higher uncertainty about the price of their public debt, should use the auction mechanism that reduces under-pricing. Results from the logit regression supported this view. Upon comparing South Africa's profile with the logit regression results, alongside a review of the literature, it becomes apparent that the proposed model does not provide a definitive answer. However, the model does aid policymakers' decision on which auction mechanism should be preferred over the other for South Africa.

Keywords: auction, discriminatory auction mechanism, government bond, logistic regression, uniform-price auction mechanism.

Declaration

I, Johan du Plessis, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfillment of the requirements for the degree Master of Management in Finance and Investment in the University of Witwatersrand, Johannesburg. It has not been submitted before any degree or examination in this or any other university.

Johan du Plessis

Signed at ……

On the …… day of ……....2012

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Chapter 1: Introduction

1.1 Purpose of the Study

The purpose of this study is to evaluate the different global government bond auction mechanisms and determine if South Africa is currently utilising the most efficient government bond issuance programme, given the country's emerging-market status. This analysis will identify certain characteristics of the country's economic and legal framework, and will determine factors from the financial markets to assess which of these characteristics will have a significant impact on the country's issuance programme (i.e., fund-raising).

1.2 Context of the Study

There is often a shortfall between governments' income and expenditure. They have a limited number of options available to them to alleviate this deficit: collect more revenue from taxpayers or borrow money from a public investor pool to fund it. Governments mainly access public debt capital markets to borrow money from investors by issuing tradable securities in the form of government bonds, notes, bills and other related securities (generically referred to as 'treasuries').

1.2.1 Brief overview

The first government borrowing to finance government deficits took the form of tontines.[1] France offered the first national tontine in 1689 and England offered the last in 1789 (Weir, 1989: 96). According to the Bank of England, the English government issued the first government bond in 1693 to raise funds to fight the war against France. Since then, governments have constantly accessed public debt capital markets to finance the shortfall between income and

[1] Tontines are forms of life annuities in which survivors benefit from the death of other participants. In simple life annuity loans the government borrowed by taking lump-sum payments in exchange for providing a stream of repayments during the lifetime of a nominee. Tontines are also referred to as 'consoles'.

expenditure. Total global public debt increased to approximately US$41.25 trillion in 2011 and the United States of America's (US') public debt is approximately 25 per cent of the global public debt burden (*The Economist*, 2012).

1.2.2 Different auction mechanisms

Since Friedman (1960) started the discussion surrounding which auction mechanism the US Treasury Department should use, academic researchers have contributed widely to the literature on government security auctions. The main focuses of the literature were on the use of auction mechanisms, primary dealers and syndications to market and distribute government securities, and the advantages and disadvantages of each (McConnachie, 1996).

Given the global public debt figure, the vast number of different government securities and the prolific research output on government security auctions, one would expect that sovereign issuers would have determined the most efficient government debt issuance structure, auction style and characteristics for their securities programme. However, after reviewing research conducted by Back and Zender (1993), Nyborg and Sundaresan (1996), Malvey and Archibald (1998), and Goldreich (2007), it has become apparent that there is an on-going robust debate about sovereign issuance procedures. The key focus of the debate pertains to different auction pricing mechanisms and the relative merits of selling government bonds by using the uniform-price auction or the discriminatory auction mechanism. The four main auction mechanisms as described by Bikhchandani and Huang (1993) are as follows:

(i) Discriminatory auction

Bidders submit the amount of securities they desire as well as the price that they are willing to pay. The bids are then ranked from high to low and the highest bid is allocated the desired amount. The process is repeated until the full amount of supply is allocated. Winning bidders pay the price that they initially submitted (Bikhchandani and Huang, 1993: 118).

(ii) Uniform-price auction

Bidders submit the amount of securities they desire as well as the price that they are willing to pay. The bids are then ranked from high to low and the highest bid is allocated the desired amount. The process is repeated until the full amount of supply is allocated. However, unlike the discriminatory auction, winning bidders all pay the price of the highest losing bid even if they submitted a higher bid price initially (p. 118)

(iii) Ascending-price auction

Bidders indicate the amount of securities they desire as well as the price that they are willing to pay. The auctioneer initiates the auction at a low price and increases the price until the demand equals the amount of supply. The bidders pay the price that equates demand and supply. This type of auction system is commonly used to auction works of art (p. 118).

(iv) Descending-price auction

The auctioneer initiates the auction at a high price and decreases the price until a bidder is willing to pay the current price for a certain amount of the objects on offer. The bidder pays the price bid for the object. This sequence is repeated until the whole supply is allocated. Tulips in the Netherlands are mainly auctioned in this fashion (p. 119).

1.2.3 Examples of divergence between auction mechanisms implemented in different countries

The South African government currently uses a primary dealer system to distribute its bonds and the uniform-price auction mechanism to determine the price that bidders will pay for their securities. In Brazil a primary dealer system and the uniform-price auction mechanism are used to issue floating-rate notes and index-linked bonds. However, the discriminatory auction mechanism is used to issue fixed-rate bonds (Figueiredo et al., 2002: 14). In contrast, the Federal

Republic of Germany distributes its bonds through the Bund Issue Auction Group and uses the discriminatory auction mechanism to price its securities (Bundesbank, 2012: 1).

The US Treasury first adopted the discriminatory auction mechanism when it began auctioning Treasury bills in 1929 and it continued to use this method when coupon-bearing securities were issued in the 1970s (Garbade and Ingber, 2005: 1). During the 1990s, the US Treasury embarked on a review of its auction procedures in collaboration with the Securities Exchange Commission and the Board of Governors of the Federal Reserve System (Chari and Weber, 1992: 2). In 1992 the US Treasury started to auction 2- and 5-year securities using the uniform-price auction mechanism and extended this mechanism to all maturities in 1998 (Goldreich, 2007: 6).

Brenner, Galai and Sade (2009) conducted a short survey to determine which auction mechanisms treasuries and central banks employed around the world. The researchers received responses from 48 countries. Their results indicated that most of the countries that they had sampled used the discriminatory auction mechanism. However, the result seems to be counter-intuitive because the largest issuer of public debt, the US, decided to change from the discriminatory auction mechanism to the uniform-price mechanism in 1998 (Goldreich, 2007: 6). This contrast between the empirical finding of Brenner et al. (2009) and the US' decision to change its auction mechanism raised the suspicion that there might be certain characteristics of the country issuing public debt that influence the auction mechanism that should be implemented.

1.3 Problem Statement

Almost all financial assets are issued by means of an auction process. To that end, a large amount has been written about the auction process with particular reference to the two main auction mechanisms: (i) the uniform-price and (ii) discriminatory auction mechanisms (Back and Zender (2001); Nyborg and Sundaresan (1996); Heller and Lengwiler (1998); Harris and Raviv (1981)). However, academics have not been able to determine the most efficient way of auctioning securities. It appears that the different auction mechanisms yield different revenue, interest payment and investor participation outcomes. The choice of auction mechanism has, in

turn, created a disparity between the amount of interest countries pay on their public debt, the amount of revenue collected from issuing debt and the composition of the investor pool. In summary, it seems that country-specific characteristics and the nature of the debt being issued could determine which auction mechanism should be implemented in pursuit of efficiency. Yet, research related to identifying these country-specific characteristics and nature of the debt being issued, which would aid the choice of auction mechanism, has not been so nuanced.

1.4 The Objective and Significance of this Study

This study will attempt to shed some light on the South African government's decision to use its current auction mechanism and will aid policymakers in enhancing or changing the existing auction mechanism in order to manage the country's public debt issuance programme. In this, idiosyncratic considerations relevant to the country's economic and legal framework, as well as determining factors taken from the financial markets and the asset being auctioned, will be used to critically review the current auction mechanism implemented by the South African government. Thus, if the study is able to identify relevant characteristics that influence the auction mechanism of choice, an appropriate auction mechanism could be identified which, in turn, would minimise the country's interest payment bill and maximise the revenue collected.

Chapter 2: Literature Review

2.1 Introduction

In this section a detailed literature review of the key focus areas of the research on this topic is undertaken. In the first part a critical review of the debate about discriminatory and uniform-price auction mechanisms is presented. In the second section the review focuses on determining explanatory variables that have been used in other macro-finance studies to articulate the relevant characteristics of the country's economic and legal framework, and on determining factors taken from the financial market and the asset being auctioned.

2.2 The Debate About Discriminatory and Uniform-Price Auction Mechanisms

As mentioned previously, there has been wide-ranging debate about uniform-price and discriminatory auction mechanisms. In this part of the literature review the researcher highlights the key findings of previous research, and contrasts and attempts to explain the different conclusions that have been reached.

Back and Zender (1993) compared the uniform-price auction with the discriminatory auction mechanism, assuming that the items on auction were independent. They illustrated that single-unit demands did not accurately describe the game theory decisions used in multiple unit treasury auctions. Bikhchandani and Huang (1993) observed that the average selling price for uniform-price auctions was higher than discriminatory auctions but the assumption that bidders only wanted one unit of the indivisible good was used. Back and Zender (1993) determined that bidders who bought more than one unit of a good were more concerned with the marginal cost of the good than the price. The steep demand curve submitted by bidders in a uniform-price auction increased the marginal cost of other bidders and thus decreased competition (this finding did not change if the number of bidders was increased) and a type of collusion occurred. The authors determined that there was collusion when a uniform-price auction was utilised. The collusion that transpired reduced the amount of revenue collected when compared to the revenue raised under the discriminatory auction mechanism.

Table 2.1 presents a summary of the pertinent works on the dominant auction mechanisms, which are discussed systematically.

Table 2.1: Summary of the empirical findings of research that has been conducted on different countries' Treasury securities markets

Author	Country/ Market	Period reviewed	Auction mechanism	Result/Findings
Umlauf (1993)	Mexican Treasury bill	1986–1991	Discriminatory: 1986–July 1990 Uniform-price: July 1990–1991	Uniform-price raises more revenue. Bidder profits increase as information dispersion increases.
Gordy (1999)	Portuguese Treasuries	June 1998–April 1993	Discriminatory	Positive correlation between number of bids, price dispersion of bids and market volatility. Bidder profits increase as quality of public information deteriorates.
Heller and Lengwiler (1998)	Swiss Treasury	3-year period	Uniform-price	Switching to a discriminatory auction mechanism would increase the government's debt finance costs by 0.2 per cent.
Nyborg et al. (2002)	Swedish Treasuries	1990–1994	Discriminatory	As volatility of prices increases, bid dispersion increases, prices are reduced and quantities of goods bid for are reduced.
Chari and Weber (1992)	US Treasuries	N/a	N/a	The uniform-price auction mechanism would yield more revenue, since bidders would have less incentive to gather costly information or shade their bids when the uniform-price mechanism is employed.
Harris and Raviv (1981)	N/a	N/a	N/a	When bidders are risk-averse, the discriminatory auction mechanism is superior in terms of expected revenue for the seller, when compared to the uniform-price mechanism.
Malvey and Archibald (1998)	US Treasuries	January 1990–July 1998	Discriminatory: January 1990–August 1992 Uniform-price: September 1992–July 1998	The auction spread is smaller under the uniform-price mechanism. Thus, the revenue collected by the US Treasury would be greater when the uniform-price mechanism is used.
Nyborg and Sundaresan (1996)	US Treasuries	July 1992–August 1993	91 discriminatory price auctions and 15 uniform-price auctions	The choice of auction mechanism impacts on when-issued market volumes, volatility and the magnitude of mark-ups.
Goldreich (2007)	US Treasuries	June 1991–December 2000	Both auction mechanisms were used during the period under review	Switching to the uniform-price mechanism would reduce the amount of under-pricing but not eliminate it.

Umlauf (1993) studied Mexican Treasury bill auctions during 1986 to 1991 and focused on the bidding behaviour of investors. The Mexican Treasury started implementing the uniform-pricing mechanism in July 1990; previously it had used the discriminatory mechanism. During the sample period, it had completed 237 auctions but the final sample size of the analysis was 207 auctions. The author determined that uniform-price auctions raised more revenue than discriminatory auctions but could not determine whether the uniform-price mechanism alleviated the problem of collusion between bidders or if it alleviated the fear of the winner's curse.[2] Umlauf's findings suggest the existence of information asymmetries between large and small bidders, and that bidder profits increase as information dispersion increases.

Back and Zender (2001) conducted a study on uniform-price auctions where the seller may cancel part of the amount of securities on offer. This study appears to resolve the contradictory findings between Back and Zender (1993) and Umlauf (1993). Back and Zender (2001) determined that when using the uniform-price mechanism, there were certain benefits to increasing the number of bidders when the auction had supply restrictions. Therefore, the differences in the findings of previous studies may be attributed to the Mexican Treasury's ability to limit the supply of securities on offer.

Gordy (1999) analysed 510 Portuguese Treasury auctions. The discriminatory auction mechanism was used and bidders could submit multiple bids during the study period. Gordy's period covered June 1988 to April 1993. The results showed that when there was a greater probability of a winner's curse, bidders would increase the number of bids and disperse prices more widely. It can thus be inferred that there is a positive correlation between the number of bids submitted, dispersion of bid prices and the measures of market volatility. Their results are consistent with Umlauf's (1993) findings which suggested that bidder profits would increase as the quality of public information deteriorated.

[2] The bidder submitting the highest bid will win the auction and receive the goods. However, it could occur that the winning bidder has overestimated the true value of the goods of auction and thus has overpaid.

Nyborg et al. (2002) analysed the bidding behaviour of over 400 Swedish Treasury auctions (multi-unit security auctions that were priced using the discriminatory auction mechanism) between 1990 and 1994. They found that the dispersion of bids swelled as volatility of prices (uncertainty) increased. These results are in line with the findings of Gordy (1999). Nyborg et al. (2002) also found that bidders reduced the price levels that they bid and quantity of securities demanded as uncertainty increased. The authors found that for bidders, auction size was a less important factor than price uncertainty. As auction sizes were increased, bidders would increase their demand by less than one to one, the price levels remained relatively unchanged and the dispersion of bids appeared to be affected marginally.

Heller and Lengwiler (1998) analysed over a three-year period whether switching from the uniform-price to the discriminatory auction mechanism would increase the Swiss Treasury's revenue. The Swiss Treasury only used the uniform-price auctions mechanism during the period analysed. Given this constraint, the authors had to transform the bids received in the auctions to hypothetical bid functions that would have occurred under the discriminatory auction mechanism. They determined that if the Swiss Treasury used the discriminatory auction mechanism, it would have increased the government's debt finance costs by 0.2 per cent. In addition to this, they also found that uniform-price auctions were strategically simpler for bidders, since bidders would reveal their true demand schedules and did not have to utilise other resources to determine other bidders' behaviour.

Chari and Weber (1992) reviewed the US Treasury auction mechanism by focusing on the information acquisition process, which is a key difference between the discriminatory and uniform-price mechanisms. During a discriminatory auction, all bidders pay the amount they bid and this leads to more bid shading than during a uniform-price auction where all winning bidders will pay the same price. Given that all bidders pay the same price for the goods, bidders would have less incentive to gather costly information or shade their bids. Chari and Weber therefore determined that the uniform-price auction mechanism would yield more revenue. The authors also argued that switching to a uniform-price mechanism would decrease the size of the when-issued Treasury market and the forward market, because price discovery (information acquisition) would be less important if every bidder paid the same price.

Harris and Raviv (1981) attempted to determine the most efficient auction mechanism, based on the way bidders adapted their bids for each auction mechanism, from the seller's point of view. During a uniform-price auction, bidders indicate their true reservation price, while during a discriminatory auction, bidders shade their bids to below their true reservation price. The model for the authors' analysis was based on the assumption that a fixed quantity of divisible goods was sold to N potential bidders who bid for one unit. Harris and Raviv (1981) found that when bidders were risk-neutral, uniform-price and discriminatory auction mechanisms were both optimal mechanisms and maximised the seller's revenue. However, their results indicated that when bidders were risk-averse, the discriminatory auction mechanism was superior in terms of expected revenue for the seller compared to the uniform-price mechanism.

Malvey and Archibald (1998) updated the major results found in the US Treasury's 1995 study entitled "Uniform-price Auctions: Evaluation of the Treasury Experience" (US Treasury, 1995). They used two different datasets: one for the analysis of the concentration of awards for different groups: discriminatory auction for January 1990 to August 1992, and uniform-price auction for September 1992 to July 1998; and another to measure the effects of auction techniques on revenues: discriminatory auction for June 1991 to August 1992, and uniform-price auction for September 1992 to September 1995. They determined the effect of the different auction mechanisms on the revenue collected by comparing the auction bid yields with the yields in the when-issued market. The authors used the auction spread (auction yields minus when-issued yields) to determine which auction mechanism yielded the greater revenue for the US Treasury. They found that the auction spread was smaller under the uniform-price mechanism. Thus, the revenue collected by the US Treasury would be greater when the uniform-price mechanism was used.

Furthermore, Malvey and Archibald (1998) examined whether the auction results from the two different mechanisms were significantly different from the when-issued yield. Under the discriminatory auction mechanism the results indicated that the auction spreads where statistically different from zero for the 2- and 5-year notes. The results were in contrast to the results obtained under the uniform-price mechanism. Under the uniform-price mechanism, the results indicated that the auction spreads were not statistically different from zero for the 2- and

5-year notes. These results suggest that the US Treasury's expected revenue was reduced under the discriminatory auction mechanism. When the dataset was updated to May 1998, the results remained consistent with the previous findings.

Nyborg and Sundaresan (1996) analysed US Treasury auctions during July 1992 and August 1993 for 91 discriminatory price auctions and 15 uniform-price auctions. The authors provide evidence that the choice between auction mechanisms impacts on when-issued market volumes, volatility and the magnitude of mark-ups, and the average difference between the auction yield and the when-issued security yield 30 minutes before the start of the auction bidding process. Nyborg and Sundaresan's (1996) contribution differs from previous studies because their dataset contains all the transactions executed by Garban Securities LLC, one of the most active US Treasury security brokers. They concluded that when-issued security trading was more active under the uniform-price mechanism and had lower post-auction volatility than under the discriminatory price auction.

In addition, Nyborg and Sundaresan (1996) performed direct tests on the difference in mean mark-ups for the two different auction mechanisms. However, the tests yielded inconclusive results. Analyses of the 2-year auctions revealed that uniform-price auction had a lower mean mark-up around 1:00 p.m. than the discriminatory auction. This result was reversed around the time the auction outcome was released. Analyses of the 5-year auctions revealed that the mean mark-up was lower in a uniform-price auction around the release time but the same results were not obtained around the 1:00 p.m. period. Nyborg and Sundaresan's (1996) results differ from the finding of Malvey and Archibald (1998) which used a longer analysis period.

Goldreich (2007) analysed the amount of under-pricing[3] for uniform-price and discriminatory auction mechanisms. The author also attempted to demonstrate the effect that the auction mechanism had on the revenue raised, assessing whether there was little bidder power or strategic behaviour. The dataset used consisted of announced results for 283 Treasury security auctions between June 1991 and December 2000, and the secondary market prices at the time of

[3] The amount by which the mean winning yield of the auction exceeds the when-issued or secondary market yield is defined as the amount of under-pricing.

the individual auctions. The author established that the average under-pricing for discriminatory auctions was 0.59 basis points. This result was statistically significant and in line with previous results obtained by other researchers. However, when analysing the uniform-price auctions, the author found the average under-pricing to be 0.32 basis points and the result were also statistically significant. The conclusion can thus be drawn that switching to the uniform-price mechanism would reduce the amount of under-pricing but not eliminate it.

Goldreich's theoretical model is one where bidders have little market power. The model established that when no single bidder had any market power, then only the discriminatory auction mechanism exhibited under-pricing in equilibrium. However, the author found that when there were a finite number of bidders, both auction mechanisms experienced under-pricing. The author found that the average amount of under-pricing observed in the auctions was indeed similar to the amounts predicted by his model.

2.3 Economic, Legal and Financial Market Characteristics that Might Influence the Auction Mechanism Decision of a Country

The purpose of this section is to identify variables that have been used in other macro-finance studies to articulate the relevant characteristics of a country's economic and legal framework, as well as to determine auction-pertinent factors from the financial market and the relevant asset being auctioned.

Consistent with the research question posed in this study, there is merit in borrowing ideas from other asset markets in order to establish whether there are certain interactions within those markets that might impact on the choice of auction mechanism. To that end, the researcher analyses literature that is relatively unrelated to the government securities market. However, the literature reviewed does establish certain links between financial market development and certain determining characteristics of the country that subsumes the public debt market. It is anticipated that the relationships pointed out by the literature under review might offer explanations that can be used to determine the auction mechanism that would manage the country's public debt issuance programme efficiently.

Brenner et al. (2009) conducted a cross-sectional multinomial logit and discriminatory analysis to establish which variables affected the choice of auction mechanism of a number of countries. The analysis indicated that countries that used the discriminatory mechanism had lower stock market capitalisation-to-gross domestic product (GDP) ratios; the legal system implemented in countries that used discriminatory and uniform-price mechanisms differed significantly and the ease-of-doing-business index was higher in countries that used a uniform-price mechanism. The main finding in the multinomial logit and discriminatory analysis was that the stock market capitalisation-to-GDP ratio correlated positively and significantly with the choice of a uniform-price mechanism. The dummy variable for civil law versus common law correlated significantly with the auction pricing mechanism but when the dummy variable for civil law versus common law and the stock market capitalisation-to-GDP ratio were used together in the regression to estimate the auction pricing mechanism, only the stock market capitalisation-to-GDP ratio remained statistically significant.

Brenner et al. (2009) looked at specific characteristics that might affect the choice of auction mechanism, using cross-section empirical analysis. They used a set of macro-variables that had been applied to study other macro-finance issues. They divided the potential explanatory variables into two groups: the first group related to specific characteristics of the asset and the second related to specific characteristics of the country that was issuing the debt. They found evidence that the UK took the riskiness and "winner's curse" of the asset being auctioned into account when determining the auction mechanism (Leong (1999) in Benner et al. (2009)). Thus, the credit risk of the sovereign was included as a proxy for the related riskiness of the security being issued. They reviewed La Porta et al.'s (1997) and Levine's (1999) research which indicated that legal and regulatory systems that gave priority to creditors had more efficient financial intermediaries. They also determined that countries in which compliance with contracts and laws was enforced effectively had better-functioning financial intermediaries which, in turn, affected economic growth through financial intermediary development.

La Porta et al. (1997) indicated that the legal system of a country influenced the size and depth of the capital markets. They also determined that countries that used civil law had weaker investor protection and less developed capital markets compared to countries that implemented common law. Given this, it can be concluded that there is more uncertainty surrounding the cash-flow repayments from government debt that is issued under a civil law legal system.

Brenner et al. (2009) included the stock market capitalisation-to-GDP ratio and "ease of doing business" as explanatory variables. This was based on research conducted by Rajan and Zingales (1998) which utilised a different method to illustrate how financial development decreased external finance cost and was supportive of economic growth. The findings of Allen et al. (2006), who determined that the structure of the real economy might influence the financial system, also contributed to the inclusion of these variables. Brenner et al. (2009) discussed literature connecting the structure of a country's financial market to political influences and determined that indexes that ranked a country's economic freedom and corruption should be included.

Levine (2000) investigated the linkage between countries' financial structure and economic growth by analysing the competing views of bank-based and market-based financial structures. He determined that there was no significant link between the financial structure of a country and the country's economic growth. Rather, his results pointed more in the direction of the financial services, as well as the legal and finance views. These views posit that financial structure was not the most efficient way to differentiate between financial systems. The results concluded that financial structure did not facilitate growth but financial systems had an important impact on growth. Levine's 2000 study is also consistent with his earlier work (Levine, 1999) and with research conducted by La Porta et al. (1997), which all found that the choice of legal system influenced financial development and thus impacted on growth.

Interesting research has been conducted on the cost of private firms going public. Ritter (1987) focused on two costs: (i) direct costs (investment banking fees) and (ii) indirect costs (under-pricing). This analysis focused on two forms of underwriting: (i) firm commitment and best effort, and (ii) the costs of both methods.[4] According to Ritter (1987: 276), "Rock's (1986) model of under pricing of initial public offers, developed in Beatty and Ritter (1986), determines that firm commitment offers will be under-priced more, the greater the *ex ante* uncertainty about an issuing firm's value." The reason for the difference in under-pricing can be attributed to the asymmetric information between informed and uninformed investors. This leads to a situation where informed investors submit more bids for under-priced offers and uninformed investors will receive an unbalanced amount of overpriced offers. This leads to a "winner's curse" scenario for uninformed investors.

Ritter's (1987) findings support the previous view that firms with higher *ex ante* uncertainty about their initial public offering price are more likely to use best effort as the preferred form of underwriting. Ritter's findings can be linked to previous studies on auction mechanisms. As mentioned previously, Goldreich (2007) measured the amount of under-pricing of Treasury

[4] During a firm commitment underwriting, the underwriter undertakes all the risk of selling the securities on offer. However, when best effort underwriting is used, the underwriter undertakes to sell the securities on offer but any unsold securities are returned to the firm issuing them.

securities as the difference between the auction yield and the yield of the security in the when-issued market. The analysis concluded that uniform-price auction mechanism reduced the amount of under-pricing relative to discriminatory auction mechanism. Previous scholars have come to the conclusion that the winner's curse is also lower for uniform-price auction than for discriminatory auctions (Bikhchandani and Huang, 1993).

Ojah and Pillay (2009) highlight the fact that there are certain characteristics of corporate borrowers that would influence the choice between the use of public and private debt. In their review of previous literature they found that larger and less opaque corporates would tend to be public borrowers; corporate stock volatility decreased the probability of utilising public debt; and that credit ratings influenced the way corporates financed themselves. Given these and other findings from the literature review, they evaluated the South African corporate debt structure and found that public debt borrowers were bigger, were more profitable, had a longer operating history and were less opaque with the information they shared.

Inoue (1999) stressed the importance of liquidity in the government securities market. He notes that the degree of liquidity is partly affected by the country's market structure and that further research should be done to determine the link between structural features of markets from a liquidity perspective. He uses two methods to measure market liquidity: (i) turnover ratios and (ii) bid-offer spreads.[5] The results he obtained were based on responses from a questionnaire that 11 governments completed and other liquidity-related data collected at the end of 1997. The turnover ratios of the countries in the study differed from 3 to 34 times. Given this wide dispersion of the turnover ratios, it can be inferred that there should be a link between liquidity of government securities and the specific market structure of that country.

[5] The turnover ratio is equal to the yearly trading volume of debt securities divided by the volume of debt outstanding. The bid-offer spreads is defined as the difference between the price or yield that securities are bought and sold at.

2.4 Summary of Guides Obtained from the Literature

The purpose of this section is to present the proposed explanatory variables that will be used to represent identifiable characteristics that are theoretically and/or intuitively considered relevant in determining the appropriate auction mechanism for a country.

2.4.1 Sovereign credit rating

Brenner et al. (2009) found evidence that the United Kingdom (UK) took riskiness of the asset being auctioned into account when determining the auction mechanism. Ojah and Pillay (2009) found evidence that the credit rating of a corporate borrower in the South African financial market influenced the way they financed themselves.

This study thus proposes to use the sovereign credit rating to determine the appropriate auction mechanism of a country.

2.4.2 Total outstanding debt as a percentage of a country's GDP

Brenner et al. (2009) introduced the World Bank's indebtedness classification of a country as a proxy for riskiness and uncertainty. This classification consists of a three-point scale: 1 severely indebted (S), 2 moderately (M) indebted and 3 less indebted (L). This study concurs with the intuition behind the original inclusion of this variable. Countries with higher debt-to-GDP ratios should be classified as riskier than countries with lower debt-to-GDP ratios because of the burden of repayment that accompanies the higher amount of debt. However, a narrower classification of indebtedness would better describe the riskiness and uncertainty of the asset under review.

This study thus proposes the inclusion of the variable, total outstanding debt as a ratio of a country's GDP.

2.4.3 Civil law versus common law

Research conducted by La Porta et al. (1997) and Levine (1999) indicated that if a country's legal and regulatory system gave priority to creditors and enforced compliance with contracts and laws effectively, it would have better-functioning financial intermediaries which, in turn, would affect economic growth through financial intermediary development. La Porta et al. (1997) indicated that the legal system of a country influenced the size and depth of the capital markets. They also determined that countries that used civil law had weaker investor protection and less developed capital markets. Government debt issued under a civil law legal system would thus have more uncertainty surrounding cash-flow repayments.

It is therefore proposed that a variable be included to illustrate the legal system implemented in the country under review.

2.4.4 Stock market capitalisation as a percentage of GDP and GDP

Brenner et al. (2009) included the variable stock market capitalisation-to-GDP ratio based on research conducted by Rajan and Zingales (1998). Rajan utilised a different method to illustrate how financial development decreased external finance cost and was supportive of economic growth. Ojah and Pillay (2009) determined during their review of previous literature that the size of the corporate borrower influenced the way that corporates financed themselves.

To this end, the variables stock market capitalisation as a percentage of GDP and GDP will be included in this study.

2.4.5 Country's historical stock market volatility

Gordy (1999) inferred that there was a positive correlation between the number of bids submitted during an auction and the measures of market volatility, and Nyborg et al. (2002) found that the dispersion of bids increased as the volatility of prices increased. These findings are comparable with Ritter's (1987) findings that firms with higher *ex ante* uncertainty about their initial public

offering price were more likely to use best effort as the preferred form of underwriting. These results were all consistent with Ojah and Pillay's (2009) findings that corporate stock volatility decreased the probability of utilising public debt.

This study believes that there is a relationship between volatility/uncertainty of the asset and financial market of the country under review, and will thus include the country's historical stock market volatility to proxy for this relationship.

2.4.6 Turnover ratio

Nyborg and Sundarasan (1996) provide evidence that the choice between auction mechanisms influences the when-issued market volumes. This is in line with the conclusion reached by Inoue (1999) that there is a definite link between liquidity of government securities and the specific market structure of the country.

This study thus proposes the inclusion of the variable turnover ratio, measured as the ratio of the total value of shares traded during a year, divided by the average stock market capitalisation during the year. It should be noted that the ratio of the yearly trading volume of public debt divided by the country's volume of outstanding debt would be a better liquidity measure of the country's government securities market. However, the data needed to calculate the variable are not freely available. Developing nations typically have better developed stock markets when compared to their government securities market. Thus, a country's stock market turnover ratio should be an appropriate alternative to indicate the liquidity of that country's financial market.

Chapter 3: Research Methodology

3.1 Research Design

The research methodology implemented in this study is based on the research conducted by Brenner et al. (2009). These authors analysed auction mechanisms used by national treasuries and central banks from around the world. Given the responses from 48 countries (based on a questionnaire), and certain characteristics of the countries and assets under review, Brenner et al. were able to present the descriptive statistics of the countries according to the auction mechanism implemented by each. However, they did not include South Africa's preferred auction mechanism in their study. Owing to the importance of the South African financial market in the African context, the non-inclusion of South Africa is unarguably an important omission.

This study therefore focuses on the South African context and attempts to update the descriptive statistics by adding additional specific characteristics. Some of the previous characteristics utilised by Brenner et al. (2009), which are now not considered relevant due to South Africa's market environment and/or absence of data, will be excluded or replaced.

While conducting their univariate analysis, Brenner et al. (2009) proposed several explanatory variables to explain a country's choice of auction mechanism. Following the extent of the literature review (as set out in Chapter 2), it is deemed wise to add and replace some of the characteristics identified by Brenner et al. (2009) in this study, particularly in the light of South Africa's and other emerging markets' "specialness". This study proposes to conduct a statistical investigation similar to that of Brenner et al. Explanations for the dissimilarities and similarities between explanatory variables utilised are contained in Table 3.1.

Table 3.1: Comparison of the proposed explanatory variables, with the explanatory variables utilised by Brenner et al. (2009)

Brenner et al. (2009)	This study
1. **Sovereign debt ratings:** Proxy of the riskiness of the asset being issued.	1. **Sovereign credit rating:** Ojah and Pillay (2009) determined during their review of previous literature that the corporate credit rating influenced the way corporates financed themselves. Hence, this study envisages that the link between corporate credit ratings and the way they finance themselves may exist in the government securities market.
2. **Indebtedness classification:** The World Bank classifies countries by their level of indebtedness. A three-point scale is used: 1 severely indebted (S), 2 moderately indebted (M) and 3 less indebted (L). Proxy for riskiness and uncertainty.	2. **Total outstanding public debt as a percentage of a country's GDP:** Given the very broad three-point scale used by the World Bank, the researcher believes that a narrower classification of indebtedness would be able to better describe the level of uncertainty/riskiness of the asset under review. This study will thus replace the World Bank's indebtedness classification with total outstanding public debt as a ratio of the country's GDP. This measure is more likely to produce more cross-variation of the time-series than the World Bank's measure.
3. **Civil law versus common law:** This variable was included after research by La Porta et al. (1997) indicated that legal systems that protected creditors and enforced contracts stimulated financial intermediary development and, in turn, affected economic growth.	3. **Civil law versus common law:** La Porta et al. (1997) indicated that the legal system of a country influenced the size and depth of the capital markets. They also determined that countries that used civil law had weaker investor protection and less developed capital markets, and would thus have more uncertainty surrounding the cash-flow repayments from government debt that was issued under a civil law legal system.
4. **Stock market capitalisation as a percentage of GDP:** Proxy for degree of financial market development.	4. **Stock market capitalisation as a percentage of GDP:** Rajan and Zingales (1998) determined how financial development decreased external finance cost and was supportive of economic growth. In this study this variable is proposed as a proxy for the degree of financial market development (size and breadth).
5. **GDP:** Proxy for the size of the country's economy.	5. **GDP:** Ojah and Pillay (2009) determined during their review of previous literature that the size of the corporate borrower influenced the way that corporates financed themselves. In this study this variable is proposed as a proxy for the size of the country's economy (measured in USD billion)
6. **The ease of doing business index and the CPI corruption index:** Proxy to rank the countries according to competitiveness, economic freedom and corruption.	6. **Country's historical stock market volatility:** Ritter (1987) determined that the *ex ante* uncertainty of an initial public offering price affected the method of underwriting. Ojah and Pillay (2009) also established that higher corporate stock volatility decreased the probability of utilising public debt. Given these findings, the researcher in this study includes the country's historical stock market volatility as a proxy of uncertainty and the amount of information asymmetry between informed and uninformed investors.
	7. **Turnover ratio:** Inoue (1999) noted that the degree of liquidity in the government securities market was partly affected by the country's market structure. The researcher in this study will thus include a ratio of the total value of shares traded during a year, divided by the average stock market capitalisation during the year of the country under review.

The other relevant contribution from Brenner et al. (2009) that motivated this study is their cross-sectional multinomial logit and discriminant analysis to determine potential country-specific factors that could impact on the choice of auction mechanism implemented by countries. However, in this study a logistic regression (where the dependent variable has a binary outcome) is implemented, instead of a multinomial logit regression for the statistical analysis. Given that this study is proposing to determine idiosyncratic considerations relevant to South Africa's economic, legal and financial market framework to guide the choice of an auction mechanism, the researcher proposes that the dependent variables should only be classified into two groups: (i) uniform-price and (ii) discriminatory auction mechanisms.

Another consideration for the choice of regression was based on the research conducted by Engle (2001), where he determines that financial data follows a non-normal distribution (heteroscedastic errors). Gujarati (2006) establishes that the Linear Probability Model (LPM) is not the best model to use when the dependent variable has a binary outcome because of the heteroscedastic error term of a binary distribution. Gujarati proposes the use of a logit model to alleviate this problem.

This study's proposed logit regression is represented as follows:

$$\gamma_{i,t} = \beta_0 + \beta_1 D_{1,creditrate_{i,t}} + \beta_2 X_{\frac{debt}{GDP_{i,t}}} + \beta_3 D_{2,Law_{i,t}} + \beta_4 X_{\frac{cap}{GDP_{i,t}}} + \beta_5 X_{GDP_{i,t}}$$
$$+ \beta_6 X_{HV_{i,t}} + \beta_7 X_{TR_{i,t}} + \varepsilon_{i,t}$$

The explanatory variables in the proposed regression model are described in Table 3.2.

Table 3.2: Explanatory variables of the proposed regression model

γ_i	γ_i=1 if the country uses a uniform-price mechanism γ_i=0 if the country uses a discriminatory mechanism
β_0	Intercept
$D_{1,creditrate_i}$	$D_{1,}$ creditratei = 1 if the country's sovereign rating is investment grade (i.e., BBB-and above) $D_{1,}$ creditratei =0 if the country's sovereign rating is non-investment grade (i.e., BB+ and below)
$X_{\frac{debt}{GDP}}$	Total outstanding public debt as a percentage of the country's GDP
D_{2,Law_i}	$D_{2,}$Lawi = 1 if the country practices civil law $D_{2,}$Lawi = 0 if the Country practices common law
$X_{\frac{cap}{GDP}}$	Stock market capitalisation as a percentage of GDP
X_{GDP}	GDP in USD billion
X_{HV}	Country's historical stock market volatility
X_{TR}	Turnover ratio: total value of shares traded during a year divided by the average stock market capitalisation during the year
$\varepsilon_{i,t}$	Error term

3.2 Data Collection

Brenner et al. (2009) conducted a survey targeted at central banks and treasuries around the world that attempted to determine the auction practices of the countries involved. The authors received responses from 48 countries. Of the countries that responded, 50 per cent used the discriminatory auction mechanism, 19 per cent used the uniform-price mechanism, 19 per cent used both mechanisms and the rest used different auction mechanisms from the ones mentioned. In contrast, this study analysed the auction mechanisms of 43 countries. It should be noted that the sample of countries analysed in these two studies are not the same but they are very similar. Table 3.3 illustrates the disparities between the sample countries of these two studies. The main justification for the differences between samples is that the data from some of the smaller countries may be unreliable and in some cases unavailable and thus a decision was taken to exclude them. The absence of African countries and the lack of representation of Brazil, Russia, India and China (BRIC) nations were also addressed in this study's sample. Brenner et al. (2009) used cross-sectional data during their analysis, whereas this study uses panel data, with a time-

series from 2005 to 2011 (Annexure A contains samples of a few countries' datasets used in the econometric analysis of this study).

Table 3.3: Disparities between the sample countries utilised in this study and the countries utilised by Brenner et al. (2009)

Countries included in the sample of this study but not in Brenner et al. (2009)	Countries included in Brenner et al.'s (2009) sample but not in this study
Chile	Bangladesh
Czech Republic	Cambodia
Egypt	Ecuador
India	Fiji
Indonesia	Korea
Nigeria	Luxembourg
Russia	Macedonia
South Africa	Mongolia
Spain	Panama
	Republic of Cyprus
	Sierra Leon
	Slovenia
	Solomon Islands
	Venezuela

Given that this study proposes to determine a model that will aid the choice of auction mechanism that countries should implement (taking into account idiosyncratic considerations relevant to their economic, legal and financial market framework), the dependent variables are classified into two groups: (i) uniform-price and (ii) discriminatory auction mechanisms; these are the two prototypical mechanisms. To that end, countries that utilise both mechanisms will be classified according to the auction mechanism that is used to issue the majority of the outstanding public debt.[6] Given these considerations, 60.5 per cent of the countries in the sample use the discriminatory mechanism and 39.5 per cent use the uniform-price mechanism. In the remainder of this section the data collection methodology, calculation, description of the explanatory variables (Table 3.4) and a summary of the basic descriptive analysis (Table 3.5) are presented.

[6] Brazil uses both auction mechanisms but the bulk of the outstanding public debt was issued with the uniform-price mechanism. Similar to Brazil, the UK uses both auction mechanisms but the majority of its outstanding public debt was issued with the discriminatory mechanism. The Czech Republic only utilises the uniform-pricing mechanism when issuing Treasury bills and Italy only utilises the discriminatory mechanism when issuing Treasury bills.

Table 3.4: Data collection methodology, calculation and description of the explanatory variables

Explanatory variable	Description
Sovereign credit rating	Standard & Poor's (S&P) long-term foreign debt rating (Bloomberg Professional Services, 2012).
Total outstanding public debt as a percentage of the country's gross domestic product (GDP)	Gross debt consists of all liabilities that require payment(s) of interest and/or principal by the debtor to the creditor at a date(s) in the future. This includes debt liabilities in the form of Special Drawing Rights (SDRs), currency and deposits, debt securities, loans, insurance, pensions and standardised guarantee schemes, and other accounts payable (International Monetary Fund, 2011).
Civil law versus common law	This is a description of a country's legal system (Central Intelligence Agency, 2012).[7]
Stock market capitalisation as a percentage of GDP	Market capitalisation (also known as 'market value') is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year. Listed companies do not include investment companies, mutual funds or other collective investment vehicles (The World Bank, 2012).
GDP	GDP at current prices, in USD billion (International Monetary Fund, 2011)
Country's historical stock market volatility	Bloomberg Professional Services (2012) uses the close-to-close method to calculate historical volatility, using a 220-day rolling volatility to calculate the historical volatility. $\sigma^2_{CtC} = \frac{1}{(N-1)\delta_t}\sum_{n=1}^{N}\left[\ln\left(\frac{Sn}{Sn-1}\right) - \left(\frac{1}{N}\sum_{n=1}^{N}\ln\left(\frac{Sn}{Sn-1}\right)\right)\right]^2$ Where observations are made after interval of length, δ_t, i.e. $S_n = S(t_0 + n\delta t)$ This is the standard estimator for the square of the volatility parameter, for a time-series. It is an unbiased estimator of geometric Brownian motions, with constant volatility and constant drift. *CtC* σ is the annualised standard deviation of the log returns (Annexure B contains all the indices and the index calculation methodology used to calculate the stock market volatility).
Turnover ratio	Turnover ratio is the total value of shares traded during the period, divided by the average market capitalisation for the period. Average market capitalisation is calculated as the average of the end-of-period values for the current period and the previous period (The World Bank, 2012)

[7] Malta has a mixed legal system comprising English common law and civil law; Nigeria has a mixed legal system comprising English common law, Islamic law (in 12 northern states) and traditional law; Norway has a mixed legal system of civil, common, and customary law; and South Africa has a mixed legal system comprising Roman-Dutch civil law, English common law and customary law. However, this study determined that common law formed the basis of the aforementioned countries' legal systems thus, for the sake of simplicity, all these countries' legal system will be classified as common law.

Table 3.5: Summary of the basic descriptive analysis of the proposed explanatory variables

Full dataset	GDP[8] (USD billion)	Debt-to-GDP ratio	Market capitalisation as a percentage of GDP	Historical volatility	Turnover ratio
Mean:	1055.16	59.82	73.80	23.00	71.06
Min:	6.01	4.10	4.78	4.02	0.66
Max:	15064.82	233.01	309.92	75.69	348.58
STDEV:	2243.15	37.49	58.36	10.41	57.50
	Percentage investment grade	Percentage below investment grade	Percentage civil law	Percentage common law	
S&P longterm Foreign debt rating	78.07%	23.93%			
Legal system			62.79%	37.21%	

Sources: Bloomberg Professional Services (2012); International Monetary Fund (2011); Central Intelligence Agency (2012); The World Bank (2012)

3.3 Methodology of Empirical Analysis

This study will utilise a logistic regression with panel data, which is different from the multinomial logit regression with cross-sectional data implemented by Brenner et al. (2009). This section highlights certain characteristics of the analytical model and dataset implemented in this study by providing a brief explanation of both.

The logit model is based on the logistic (cumulative) distribution function and uses a regression to obtain a *p*-value that can be used to compute the predicted probability of a dichotomous outcome. An LPM can also be used to estimate a model with a binary dependent variable. However, the major weakness of the LPM model is that it assumes a linear relationship between the explanatory variables and the probability of the dependent variable and there is no guarantee that the estimated value of the dependent variable will be bounded between 0 and 1. The logit model remedies the defects of the LPM and does not assume a linear relationship between the dependent and independent variables and the *p*-value ranges between 0 and 1 (Gujarati, 2006).

[8] GDP is measured at current prices as mentioned in Table 3.4.

Panel or longitudinal data comprise cross-sectional units measured over multiple periods. This allows analysis to be conducted over a period instead of just at a certain point in time. Brooks (2008) illustrates that panel data can be used to analyse increasingly multifaceted problems and a wider range of issues than time-series or cross-sectional data respectively. The combination of time-series and cross-sectional data could mitigate the problem of multicollinearity and by structuring the model in a certain way it does alleviate the impact of omitted variable bias. The panel data approach particularly incorporates the dynamics of the relevant study variables when estimating test statistics.

To that end, it is deemed appropriate to use panel data in the logistic regression for the empirical part of this research. Given the complexity of the research question at hand, limited data availability and the related economic relevance, it is prudent to use this methodology due to its remedial effects in dealing with some of the shortcomings of other methods.

Chapter 4: Empirical Analysis

4.1 Introduction

This empirical analysis of this study is carried out using data on 43 different countries over the period 2005 to 2011. The focus of the study is to determine idiosyncratic considerations that guide the country's Treasury department's choice of an auction mechanism. It is proposed that the dependent variable be a dichotomous variable reflecting uniform-price and discriminatory auction mechanisms. It was deemed necessary to do a basic descriptive analysis on the proposed explanatory variables. The data are analysed by grouping the different countries according to the auction mechanism predominantly implemented when issuing government debt. The reason for this is to determine if there are any disparities between the descriptive statistics of the proposed explanatory variables.

Summaries of the basic descriptive analysis of the different countries, when grouped by which auction mechanism they deployed in issuing government debt, are presented in Tables 4.1 and 4.2 (17 countries use the uniform-price auction mechanism and 23 countries use the discriminatory auction mechanism). By comparing the descriptive statistics, it becomes apparent that a larger portion of countries that implement the discriminatory auction mechanism are rated investment grade, have a civil law system and have higher debt-to-GDP ratios than those utilising the uniform-price mechanism. However, GDP and stock market capitalisation as a percentage of GDP are substantially higher for countries that implement a uniform-price mechanism. All the other explanatory variables are relatively similar between the two auction types.

Table 4.1: Summary of the basic descriptive analysis of the proposed explanatory variables of countries that utilise the uniform-price auction mechanism when issuing government debt

Full dataset: Uniform auction mechanism	**GDP (USD billion)**	**Debt-to-GDP ratio**	**Market capitalisation as a percentage of GDP**	**Historical volatility**	**Turnover ratio**
Mean:	1 305.94	50.50	90.53	23.74	69.38
Min:	15.98	4.10	9.58	4.02	1.17
Max:	15 064.82	121.07	309.91	75.69	348.58
STDEV:	3241.70	29.89	75.78	11.11	64.28
	Percentage investment grade	Percentage below investment grade	Percentage civil law	Percentage common law	
S&P longterm Foreign debt rating	63.02%	26.98%			
Legal system			58.88%	41.12%	

Sources: Bloomberg Professional Services (2012); International Monetary Fund (2011); Central Intelligence Agency (2012); The World Bank (2012)

Table 4.2: Summary of the basic descriptive analysis of the proposed explanatory variables of countries that utilise the discriminatory auction mechanism when issuing government debt

Full dataset: Discriminatory auction mechanism	**GDP (USD billion)**	**Debt-to-GDP ratio**	**Market capitalisation as a percentage of GDP**	**Historical volatility**	**Turnover ratio**
Mean:	891.19	65.91	62.78	22.55	72.16
Min:	6.01	7.76	4.78	6.50	0.66
Max:	5 855.38	233.01	155.24	54.45	269.82
STDEV:	1 191.88	40.64	39.85	9.95	52.72
	Percentage investment grade	Percentage below investment grade	Percentage civil law	Percentage common law	
S&P longterm Foreign debt rating	87.91%	12.09%			
Legal system			65.38%	34.62%	

Sources: Bloomberg Professional Services (2012); International Monetary Fund (2011); Central Intelligence Agency (2012); The World Bank (2012)

Given the sizeable differences observed between the minimum and maximum as well as standard deviation of some of the explanatory variables for both groups, an approach of grouping the countries by a different classification has been encouraged. The World Bank classifies countries into three different income groups. The countries relevant to this study are labelled as (i) low-, (ii) middle- and (iii) high-income countries, according to the World Bank's classifications and are illustrated in Table 4.3.

Table 4.3: World Bank Country Classification of the countries in the dataset

Country	Classification	Country	Classification
Ghana	Low	Australia	High
India	Low	Austria	High
Nigeria	Low	Belgium	High
Argentina	Middle	Canada	High
Brazil	Middle	Finland	High
Chile	Middle	France	High
Colombia	Middle	Germany	High
Czech Republic	Middle	Greece	High
Egypt	Middle	Ireland	High
Hungary	Middle	Israel	High
Indonesia	Middle	Italy	High
Jamaica	Middle	Japan	High
Latvia	Middle	Malta	High
Lithuania	Middle	New Zealand	High
Mauritius	Middle	Norway	High
Mexico	Middle	Portugal	High
Poland	Middle	Singapore	High
Russia	Middle	Spain	High
South Africa	Middle	Sweden	High
Trinidad and Tobago	Middle	Switzerland	High
Turkey	Middle	United States of America	High
		United Kingdom	High

Source: OECD (2012)

This study considers it functional to analyse low- and middle-income countries together and high-income countries separately. Upon comparing the descriptive statistics, it becomes apparent that high-income countries have larger GDPs, higher debt-to-GDP ratios, higher stock market capitalisation as a percentage of GDP and a higher stock market turnover ratio than the low- and

middle-income group. It should also be noted that 98.7 per cent of high-income countries are rated investment grade and only 56.46 per cent of the low- and middle-income group are rated investment grade. The divergences of legal systems are much larger for the low- and middle-income group and the vast majority of countries in this group use the civil law system (Tables 4.4 and 4.5).

Table 4.4: Summary of the basic descriptive analysis of low- and middle-income countries in the dataset

World Bank Country Classification: Low- and middle-income countries	**GDP (USD billion)**	**Debt-to-GDP ratio**	**Market capitalisation as a percentage of GDP**	**Historical volatility**	**Turnover ratio**
Mean:	409.20	45.67	57.46	23.62	40.01
Min:	6.49	4.10	4.78	4.02	1.14
Max:	2 517.93	143.36	291.28	75.69	162.70
STDEV:	503.16	29.71	54.72	10.76	39.05
	Percentage investment grade	Percentage below investment grade	Percentage civil law	Percentage common law	
S&P longterm Foreign debt rating	56.46%	43.54%			
Legal system			71.42%	28.58%	

Sources: Bloomberg Professional Services (2012); International Monetary Fund (2011); Central Intelligence Agency (2012); The World Bank (2012)

Table 4.5: Summary of the basic descriptive analysis of high-income countries in the dataset

World Bank Country Classification: High-income countries	**GDP (USD billion)**	**Debt-to-GDP ratio**	**Market capitalisation as a percentage of GDP**	**Historical volatility**	**Turnover ratio**
Mean:	1 671.75	73.32	89.10	22.43	100.49
Min:	6.01	9.63	13.47	7.54	65.67
Max:	15 064.82	233.10	309.92	54.45	348.58
STDEV:	2 973.38	39.91	57.84	10.07	56.77
	Percentage investment grade	Percentage below investment grade	Percentage civil law	Percentage common law	
S&P longterm Foreign debt rating	98.70%	1.30%			
Legal system			54.45%	45.46%	

Sources: Bloomberg Professional Services (2012); International Monetary Fund (2011); Central Intelligence Agency (2012); The World Bank (2012)

On analysing the descriptive statistics of the countries that implement uniform-price or the discriminatory auction mechanism, and grouping all the countries in the dataset by the World Bank Country Classification, it becomes apparent that it will be useful to determine three different logistic regressions, as described in the next paragraph. This would assist with determining the most appropriate auction mechanism for the country under review, in this case South Africa, when issuing government debt.

Firstly, a model would be determined for all 43 countries in the dataset (full dataset), and thereafter the 43 countries would be divided into two different groups, according to the World Bank Country Classification: (i) a low- and middle-income countries group, and (ii) a high-income countries group. Subsequent models would be determined for these individual groups. The divergences of the descriptive statistics of the explanatory variables for the different groups are potentially indicative of the fact that the explanatory variables might have unique effects on each of the groups.

4.2 Logit Regression Results and Analysis

4.2.1 Model specification

Logit regression equation for the full dataset[9]:

$$\gamma_{i,t} = \beta_0 + \beta_1 D_{1,creditrate\ i,t} + \beta_2 X_{\frac{debt}{GDP}\ i,t} + \beta_3 D_{2,Law\ i,t} + \beta_4 X_{\frac{cap}{GDP}\ i,t} + \beta_5 X_{GDP\ i,t} + \beta_6 X_{HV\ i,t} + \beta_7 X_{TR\ i,t} + \varepsilon_{i,t}$$

Logit regression equation for low- and middle-income countries:

$$\gamma_{i,t} = \beta_0 + \beta_1 D_{1,creditrate\ i,t} + \beta_2 X_{\frac{debt}{GDP}\ i,t} + \beta_3 D_{2,Law\ i,t} + \beta_4 X_{\frac{cap}{GDP}\ i,t} + \beta_5 X_{GDP\ i,t} + \beta_6 X_{HV\ i,t} + \beta_7 X_{TR\ i,t} + \varepsilon_{i,t}$$

Logit regression equation for high-income countries:

$$\gamma_{i,t} = \beta_0 + \beta_1 D_{1,creditrate\ i,t} + \beta_2 X_{\frac{debt}{GDP}\ i,t} + \beta_3 D_{2,Law\ i,t} + \beta_4 X_{\frac{cap}{GDP}\ i,t} + \beta_5 X_{GDP\ i,t} + \beta_6 X_{HV\ i,t} + \beta_7 X_{TR\ i,t} + \varepsilon_{i,t}$$

All variable input is as follows (see Table 3.2):

γ_i	γ_i=1 if the country uses a uniform-price mechanism γ_i=0 if the country uses a discriminatory mechanism
β_0	Intercept
$D_{1,creditrate_i}$	$D_{1,\ creditratei}$ = 1 if the country's sovereign rating is investment grade (i.e., BBB-and above) $D_{1,\ creditratei}$ =0 if the country's sovereign rating is non-investment grade (i.e., BB+ and below)
$X_{\frac{debt}{GDP}}$	Total outstanding public debt as a percentage of the country's GDP
D_{2,Law_i}	$D_{2,Lawi}$ = 1 if the country practices civil law $D_{2,Lawi}$ = 0 if the Country practices common law
$X_{\frac{cap}{GDP}}$	Stock market capitalisation as a percentage of GDP
X_{GDP}	GDP in USD billion
X_{HV}	Country's historical stock market volatility
X_{TR}	Turnover ratio: total value of shares traded during a year divided by the average stock market capitalisation during the year
$\varepsilon_{i,t}$	Error term

[9] The logit regression results of all three datasets can be found in Table 4.6

4.2.2 Model evaluation

(i) Full dataset

Results from the estimation of the model, using the full dataset, indicate that the likelihood ratio chi-square test statistic (LR chi-squared) is 84.151[10] (see Table 4.6). The LR chi-squared test examines the null hypothesis, namely that at least one of the explanatory variables in the model is important in influencing the choice of auction mechanism. Prob>chi2 indicates the probability of obtaining the chi-square statistic, if the explanatory variables have no effect on the dependent variable. Upon comparing the *p*-value of the regression with the critical value of 1 per cent, it can be determined that the model is statistically significant and at least one of the regression coefficients is not equal to zero. The predicted model is statistically significant at the 99 per cent confidence interval. The pseudo R-squared for the model is 0.257.[11]

(ii) Low- and middle-income countries

The LR chi-squared test statistic, for the low- and middle-income countries, is 92.419 and the Prob>chi-squared is 0.000. The predicted model is statistically significant at the 99 per cent confidence interval. The pseudo R-squared for the model is 0.57.

(iii) High-income countries

The LR chi-squared test statistic, for high income countries, is 31.633 and the Prob>chi-squared is 0.000. The predicted model is statistically significant at the 99 per cent confidence interval. The pseudo R-squared for the model is 0.2062.

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[10] LR chi-squared figure is calculated by multiplying the difference between the log likelihood of the intercept-only model and the log likelihood of the current model by negative two.

[11] The pseudo R-squared should not be confused with the R-squared that is found in ordinary least squares (OLS) regression. It does not measure the proportion of variance of the dependent variable that is explained by the variances in the explanatory variables. Unlike the R-squared that is found in OLS regression, the pseudo R-squared indicates the value gained from adding new variables to a model.

4.2.3 Interpretation of the regression findings

In this section the statistically significant explanatory variables of all three logit regressions are discussed and interpreted. As stated previously, a decision has been made to limit the dependent variable, namely the auction mechanism, to a binary outcome. If the dependent variable equals 1, then the country under review would be utilising the uniform-price auction mechanism, and all the bidders concerned in the auction would pay the same price for the security even if their initial bid were higher. To that end, if the dependent variable equalled 0, then the country under review would be utilising the discriminatory auction mechanism and winning bidders would be allocated securities at the price they initially bid for.

During the statistical analysis, several statistically significant explanatory variables were determined. However, some of the explanatory variables did not have significant effects as was expected, and one of the variables recorded a contrary sign on the dependent variable when the full dataset was classified into the sub-groups.

The literature review revealed findings by Ritter (1987) that supported the views that firms with higher *ex ante* uncertainty about their initial public offering price were more likely to use best effort as the preferred form of underwriting to alleviate the problem of under-pricing. When Ritter's findings are compared with Goldreich's (2007) study, which concluded that uniform-price auction mechanism reduced the amount of under-pricing relative to discriminatory auction mechanism, it is intuitively logical to infer that countries with higher uncertainty about the price of their public debt should use the auction mechanism that reduces under-pricing, namely the uniform-price auction mechanism.

The variables: sovereign credit rating, total outstanding public debt as a percentage of a country's GDP and historical stock market volatility, were initially proposed to proxy the risk factors, uncertainty and volatility of the country issuing debt, and the characteristics of the country's financial market and the asset being auctioned. It is suggested that countries with higher uncertainty about the price of their public debt should use the auction mechanism which reduces under-pricing and, therefore, it would be expected that any variable that increased

uncertainty, risk or volatility should increase the probability of using the uniform-price auction mechanism by the country under review.

According to the regression results of the full dataset and the low- and middle-income group, as a country's sovereign credit rating changes from below investment grade (0) to investment grade (1), the predicted probability that the country uses the uniform-price auction mechanism decreases by 54 and 86 percentage points respectively (as per the marginal effect of the variable[12]). If a country's historical stock market volatility increases, the chances of using the uniform-price mechanism increase by 0.83 percentage points for the full dataset. These findings concur with the logic of this study. However, the regression analysis of total outstanding public debt as a percentage of the country's GDP had a counter-intuitive outcome. It was proposed that countries with higher debt-to-GDP ratios should be classified as riskier than countries with lower debt-to-GDP ratios because of the burden of repayment that accompanies the higher amount of debt. In contrast with the study's expectation, the regression analysis indicates that countries with higher debt-to-GDP ratios tend to shy away from using the uniform-price auction mechanism and prefer the discriminatory auction mechanism. A one-unit increase in the debt-to-GDP ratio of a country would thus decrease the probability of using the uniform-price mechanism by 0.38 and 1.65 percentage points for the full dataset and the low- and middle-income group. Considering this outcome, it may be possible that countries with higher debt-to-GDP ratios signal their ability to service debt, and thus mitigates the information asymmetry between the issuer and investors.

The variable, turnover ratio, exhibited two different regression results when the low- and middle-income group and the high-income group were analysed. During the analysis of the low- and middle-income group, it was found that when the turnover ratio increased by one unit, the predicted probability of the country under review using the uniform-price mechanism decreased by 1.19 percentage points. Given that the turnover ratio was used as a proxy to illustrate financial market liquidity, the regression result supports the economic suspicion that liquid markets aid price discovery and thus decreases uncertainty of asset prices. However, during the analysis of the high-income group, it was determined that as the turnover ratio increased, the predicted

[12] Marginal effect of a variable= $P(Y=1|X)*P(Y=0|X)*$coefficient of the variable

probability of the country under review, using the uniform-price mechanism, increased by 0.26 percentage points. The very small positive effect that this variable has on the high-income group does not concur with this study's expectation.

The variables, GDP and stock market capitalisation as a percentage of GDP, were initially included in this analysis because Brenner et al. (2009) proposed that the variables were proxies for the degree of economic development and the size of a country's economy. Rajan (1998) illustrated how financial development decreased external finance cost and was supportive of economic growth. Ojah and Pillay (2009) determined that the size of the corporate borrower influenced the way that corporates financed themselves. The regression analysis indicates that an increase in the stock market capitalisation as a percentage of GDP for all three datasets would increase the chances that the country would use the uniform-price mechanism to issue public debt by 0.45, 1.4 and 0.25 percentage points respectively. GDP is only statistically significant for the full-dataset and the low- and middle-income group, and indicates that as a country's GDP grows, the predicted probability of implementing the uniform-price mechanism increases by 0.01 and 0.0001 percentage points respectively.

Even though the dummy variable, civil law versus common law, was not significant for any of the groups analysed, it is considered necessary to mention its effect. According to the regression result of the full dataset, if a country changes its legal system from common law (0) to civil law (1), the predicted probability that the country uses the uniform-price auction mechanism appears to be positive. This result is consistent with the findings of La Porta et al. (1997) and in line with the expectation of this study. La Porta et al. indicated that countries using civil law had the weakest investor protection and less developed capital markets. These findings would indicate that there is more uncertainty surrounding the cash-flow repayments from government debt that were issued under a civil law legal system.

Table 4.6: Logit regression results: Dependent variable is 1 if auction mechanism is uniform-price and 0 if it is discriminatory

Explanatory variables	Full dataset			Low and middle income			High income		
	Coefficient	***t*-ratio**	**Marginal effect**	**Coefficient**	***t*-ratio**	**Marginal effect**	**Coefficient**	***t*-ratio**	**Marginal effect**
Intercept	-0.4074	-0.62		1.5379	0.92		-4.53896	-4.76***	
Sovereign credit rating	-2.44432	-6.11***	-0.5445	-5.28286	-4.61***	-0.8578	(Omitted)[13]		
Total outstanding public debt as a percentage of the country's GDP	-0.01684	-3.56***	-0.0038	-0.06607	-5.25***	-0.0165	0.00368	0.66	0.00064
Civil law versus common law	0.56356	1.46	0.1224	1.30632	1.06	0.3059	-0.29725	-0.52	-0.0519
Stock market capitalisation as a percentage of GDP	0.02024	5.43***	0.0045	0.05586	4.74***	0.0140	0.01411	3.35***	0.0025
GDP	0.00028	3.24***	0.0001	0.00276	3.35***	0.0007	0.000005	0.06	0.000001
Country's historical stock market volatility	0.03687	2.26**	0.0083	0.04861	1.45	0.0122	0.015992	0.66	0.0028
Turnover ratio	-0.00445	-1.02	-0.0010	-0.04752	-4.15***	-0.0119	0.01525	2.1**	0.0026
Note: *, ** and *** denote significance at the 10%, 5% and 1% levels respectively									
Model information:									
Number of observations	248			117			130		
Log likelihood	-121.992			-34.85			-60.8864		
Log likelihood chi-square (LR chi2)	84.151			92.419			31.633		
Prob>chi-squared	0.000			0.000			0.000		
Pseudo R-squared	0.257			0.57			0.2062		

[13] The results of the variable are omitted because there was no cross-variation during the analysis.

4.3 Limitations and Observations of the Empirical Analysis

The first limitation of this study is the limited number of observations available. The analysis only includes data from 43 different countries over a period of seven years. This problem was amplified when the dataset was divided into low- and middle-income, and high-income groups. The second is that some of the countries in the study use multiple auction mechanism and have multifaceted legal systems; given the choice of regression analysis the countries' auction mechanism and legal system had to be reclassified to suit the relevant model. The final limitation is the inadequate guide (the literature) on logit regression analysis when using panel data and the relevant statistical test that should be performed.

During the analysis, sizeable differences were observed between the minimum and maximum, the large standard deviation of some of the explanatory variables, and the presence of outliers in the study. To address these issues, some of the variables were transformed (e.g., logging the data) and the outliers were omitted. However, these actions did not have a material effect on the explanatory power of the coefficients. During the period reviewed, no country changed its auction mechanism. In the past, several countries changed their auction mechanism in order to issue debt. However, the availability of this data is extremely limited and credibility of some of the data sources can be questioned, limiting the study period under review.

4.4 Critical Review of South Africa's Auction Mechanism

This study set out to evaluate South Africa's current auction mechanism and aid policymakers in enhancing or changing the current mechanism in order to manage the policy around public debt in the most efficient way. In order to evaluate the auction mechanism, South Africa's unique characteristics will be scrutinised by comparing them to the logit regression results and certain findings that emerged during the literature review.

It was previously deemed intuitively correct to infer that countries with higher uncertainty about the price of their public debt should use that auction mechanism which reduces under-pricing, namely uniform-price mechanism. Results from the logit regressions supported this view.

South Africa can be described as a middle-income emerging-market economy with well-functioning financial markets. South Africa currently uses the uniform-price mechanism when issuing its public debt and has an investment grade credit rating. According to results from the logit regression, the investment grade credit rating would decrease the probability of South Africa using the uniform-price auction mechanism. However, the variable sovereign credit rating had a binary outcome, resulting in a classification that was too broad, which could give a misrepresentation of the actual risk involved by investing in government debt. The regression analysis showed that as a country's total outstanding public debt as a percentage of GDP increased, the probability of using the uniform-price mechanism decreased. This result has been attributed to the impact that this ratio could have on mitigation of information asymmetries between investors and issuers. This impact would, in turn, affect price discovery and uncertainty pertaining to the country's public debt. South Africa's total outstanding public debt as a percentage of GDP is far below the mean of the countries in this study. Because of this, the probability of using the uniform-price mechanism increases.

South Africa has a mixed legal system comprising civil, common and customary law. It has been determined that common law formed the basis of the legal system. Research conducted by La Porta et al. (1997) indicated that there was more uncertainty surrounding the cash-flow repayments from government debt that were issued under a civil law legal system. The regression results indicated that if a country changed its legal system from common law (0) to civil law (1), the predicted probability that the country used the uniform-price auction mechanism increased. According to these findings, the probability of South Africa using the uniform-price mechanism should decrease. However, this result was not statistically significant per the regression analysis.

South Africa's stock market capitalisation as a percentage of GDP is larger than the mean of the countries in the survey but its GDP is far lower than the mean GDP of the countries in the survey. The regression results for the variables stock market capitalisation as a percentage of GDP and GDP, indicate that a one-unit increase in either variable will increase the country's probability of using the uniform-price mechanism when issuing public debt. However, the interpretation of the results is not straightforward because the presence of outliers in the dataset

can distort the mean of these variables. This provides a weak guide for the South African situation.

Gordy (1999) inferred that there was a positive correlation between the number of bids submitted during an auction and the measures of market volatility, and Nyborg et al. (2002) found that the dispersion of bids increased as the volatility of prices increased. These results are consistent with Ojah and Pillay's (2009) findings that corporate stock volatility decreased the probability of utilising public debt. These findings are all consistent with the idea that an increase in volatility subsequently increases the uncertainty of the true value of a security. The results from the regression used in this study correspond with this idea and suggest that an increase in the country's historical stock market volatility would increase the probability that the country would use the uniform-price mechanism. South Africa's historical stock market volatility is comparable with the mean of the sample countries. Thus, the historical stock market volatility is not excessively high but definitely something that needs to be considered when choosing an auction mechanism.

Nyborg and Sundarasan (1996) provide evidence that the choice between auction mechanisms influences the when-issued market volumes. This is in line with Inoue's (1999) conclusion that there is a definite link between liquidity of government securities and the specific market structure of the country. The regression results also indicate that there is a link between the liquidity of a country's financial market, proxied by turnover ratio, and the auction mechanism the country uses to issue debt. South Africa's turnover ratio is much lower than the average turnover ratio of the full dataset but it is marginally higher than the mean of the low- and middle-income group. Hence, it can be concluded that South Africa's financial markets are less liquid when compared to all the countries in the dataset but provide above-average liquidity when compared to the low- and middle-income group. When South Africa's turnover ratio is compared with the full dataset, it can be inferred that the probability of using the uniform-price auction mechanism increases.

Upon comparing South Africa's profile with the logit regression results, combined with the literature review conducted, it becomes apparent that the proposed model does not provide a

definitive answer. However, the model does aid policymakers' decision on which auction mechanism should be preferred over the other for South Africa. The model has identified several variables that make economic sense and form key considerations when choosing the appropriate auction mechanism that a country should implement. South Africa's overall characteristics display signs of uncertainty, volatility, lack of liquidity and a suggestion of high credit risk. Thus, on balance, the most efficient auction mechanism is the current uniform-price auction mechanism.

Chapter 5: Conclusion

This study set out to evaluate the different government bond auction mechanisms and determine whether or not South Africa is currently utilising the most efficient government bond issuance programme, given the country's characteristics. The literature review conducted was unable to identify the most efficient auction mechanism definitively. In several instances the literature review presented conflicting results pertaining to the different auction mechanisms. The choice of auction mechanism created a disparity between the amount of interest countries paid on their public debt, the amount of revenue collected from issuing debt and the composition of the investor pool.

Owing to these conflicting results, it was determined that an analysis should be conducted to identify pertinent characteristics of South Africa's economic and legal framework, and to determine factors from the financial markets. This would aid with the assessment of these characteristics and determine which of them would have a significant impact on the country's issuance programme. Several characteristics from other macro-finance studies were identified. They represented the risk related to investing in the country, the country's debt-to-GDP ratio, the country's legal system, the size of the country's economy, financial market development, and the liquidity and volatility of the country's financial market.

The logistic regression, using panel data, was able to identify the impact that these characteristics would have on a country's choice of auction mechanism. Many of the characteristics identified concurred with this study's proposed effects and with research conducted on initial public offerings of stocks. The literature review revealed findings by Ritter (1987) that supported previous views that firms with higher *ex ante* uncertainty about their initial public offerings were more likely to use best effort as the preferred form of underwriting to alleviate the problem of under-pricing. When Ritter's findings are compared to Goldreich's (2007) study, it is logical to infer that countries with higher uncertainty should use the auction mechanism that reduced under-pricing (i.e., uniform-price mechanism). The characteristics utilised in the regression that represented uncertainty (i.e., risk, volatility and liquidity) all indicated that as uncertainty increased, a country's probability of using the uniform-price mechanism also increased.

However, the model was unable to determine, definitively, which was the most efficient auction mechanism to implement in South Africa when issuing public debt. The model does aid policymakers' decision on which auction mechanism the country should implement. South Africa's overall characteristics display signs of uncertainty, volatility, lack of liquidity and a suggestion of high credit risk. Thus, on a balance of probability, the current auction mechanism, namely the uniform-price auction mechanism, appears to be more efficient than the discriminatory auction mechanism. However, South Africa's recent inclusion in the Citigroup's World Government Bond Index should address some of the nuisance of uncertainty and liquidity. Given the considerations mentioned previously, the ever-evolving nature of financial markets and the rapid change in the world's economic architecture, it becomes pertinent for countries to evaluate their auction mechanism of choice on an ongoing basis.

Given the encouraging results obtained from this study, it is proposed that further research be nuanced to identify more idiosyncratic considerations to guide the choice of auction mechanism.

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Annexures

Annexure A: Sample of the Dataset Used in the Econometric Analysis of this Study

Country	Type of auction	Sovereign debt rating	GDP (USD billion)	Debt-to-GDP ratio	Civil versus common law	Market capitalisation to GDP	HVOL	Turnover ratio
Argentina								
2005	U	B-	183.00	87.13	Civil	33.56	26.11	30.44
2006	U	B+	214.03	76.46	Civil	37.25	23.33	6.42
2007	U	B+	262.09	67.10	Civil	33.24	23.77	9.92
2008	U	B-	328.13	58.52	Civil	16.01	47.60	19.31
2009	U	B	310.35	58.70	Civil	15.93	35.17	5.39
2010	U	B	369.99	49.10	Civil	17.33	25.44	4.58
2011	U	B	435.18	43.35	Civil		31.94	4.80
Australia								
2005	D	AAA	737.20	10.85	Common	115.52	10.48	77.97
2006	D	AAA	784.46	9.92	Common	146.25	13.82	86.98
2007	D	AAA	953.66	9.63	Common	151.54	18.17	110.50
2008	D	AAA	1,061.04	11.71	Common	65.00	34.27	103.11
2009	D	AAA	988.58	16.92	Common	136.07	20.28	78.78
2010	D	AAA	1,237.36	20.52	Common	128.50	15.98	90.08
2011	D	AAA	1,507.40	22.82	Common		20.94	94.00
Austria								
2005	D	AAA	303.45	64.63	Civil	41.06	14.15	43.56
2006	D	AAA	322.64	62.81	Civil	59.35	21.99	50.41
2007	D	AAA	372.83	60.67	Civil	61.43	21.59	57.82
2008	D	AAA	416.62	63.75	Civil	17.44	50.69	69.45
2009	D	AAA	382.07	69.63	Civil	14.06	35.80	40.57
2010	D	AAA	377.38	72.15	Civil	17.99	24.56	79.36
2011	D	AAA	425.09	72.33	Civil		31.04	51.60
Belgium								
2005	D	AA+	377.77	92.13	Civil	76.61	9.38	44.76
2006	D	AA+	399.98	88.14	Civil	99.27	14.34	48.46
2007	D	AA+	459.25	84.19	Civil	84.24	17.57	65.35
2008	D	AA+	506.72	89.60	Civil	33.13	38.83	76.48
2009	D	AA+	472.10	96.20	Civil	55.49	23.34	59.60
2010	D	AA+	467.78	96.67	Civil	57.62	19.80	42.00
2011	D	AA	529.05	94.56	Civil		25.93	43.00

Country	Type of auction	Sovereign debt rating	GDP (USD billion)	Debt-to-GDP ratio	Civil versus common law	Market capitalisation to GDP	HVOL	Turnover ratio
Brazil								
2005	U	BB-	890.05	69.15	Civil	53.80	25.29	38.32
2006	U	BB	1,093.49	66.66	Civil	65.30	24.76	42.93
2007	U	BB+	1,378.19	65.18	Civil	100.32	28.42	56.21
2008	U	BBB-	1,655.09	63.55	Civil	35.66	54.45	74.27
2009	U	BBB-	1,600.84	68.06	Civil	73.21	29.62	73.91
2010	U	BBB-	2,090.31	66.84	Civil	74.03	20.15	66.43
2011	U	BBB	2,517.93	64.98	Civil		25.99	69.30
Canada								
2005	D	AAA	1,133.76	71.61	Common	130.62	25.29	63.57
2006	D	AAA	1,278.61	70.26	Common	133.01	24.76	81.11
2007	D	AAA	1,424.07	66.52	Common	153.54	28.42	84.66
2008	D	AAA	1,502.68	71.11	Common	66.85	54.45	111.05
2009	D	AAA	1,337.58	83.30	Common	125.81	29.62	92.40
2010	D	AAA	1,577.04	83.95	Common	137.24	20.15	71.11
2011	D	AAA	1,758.68	84.12	Common		19.52	74.80
Chile								
2005	U	A	118.29	7.28	Civil	115.39	11.89	14.89
2006	U	A	146.79	5.26	Civil	118.93	12.22	18.49
2007	U	A+	164.25	4.10	Civil	129.57	20.45	22.96
2008	U	A+	170.61	5.18	Civil	77.56	28.30	21.17
2009	U	A+	161.08	6.23	Civil	130.22	16.47	21.97
2010	U	A+	203.30	9.19	Civil	167.90	11.69	19.71
2011	U	A+	243.05	10.49	Civil		23.16	18.60
Colombia								
2005	U	BB	146.59	38.54	Civil	31.40	21.65	17.86
2006	U	BB	160.69	36.78	Civil	34.52	40.89	22.15
2007	U	BB+	210.57	32.69	Civil	49.16	18.76	13.07
2008	U	BB+	235.72	30.82	Civil	35.57	30.25	13.21
2009	U	BB+	234.18	35.82	Civil	56.52	15.85	11.75
2010	U	BB+	289.43	36.01	Civil	72.35	15.74	13.44
2011	U	BBB	321.46	35.92	Civil		19.64	13.30
Czech Republic								
2005	D	A-	124.55	29.67	Civil	30.79	18.13	118.60
2006	D	A-	142.61	29.43	Civil	34.08	21.41	75.62
2007	D	A	174.22	28.96	Civil	42.14	17.81	68.73
2008	D	A	216.09	29.95	Civil	22.61	50.55	70.39

Country	Type of auction	Sovereign debt rating	GDP (USD billion)	Debt-to-GDP ratio	Civil versus common law	Market capitalisation to GDP	HVOL	Turnover ratio
2009	D	A	190.20	35.37	Civil	27.70	31.57	40.59
2010	D	A	192.03	38.54	Civil	22.41	21.91	29.42
2011	D	AA-	220.34	41.13	Civil		23.18	38.00
Egypt								
2005	U	BB+	89.79	112.80	Civil	88.83	27.20	42.97
2006	U	BB+	107.38	98.83	Civil	86.97	32.54	54.82
2007	U	BB+	130.35	87.12	Civil	106.70	17.11	45.61
2008	U	BB+	162.44	74.66	Civil	52.74	42.97	61.85

Annexure B: Index Calculation Methodology of the Indices Used to Calculate the Stock Market Volatility of Each Country in the Dataset (Source: Bloomberg PLC)

Country and index name	Index description and calculation methodology
Argentina: The Argentina Merval Index	The Argentina Merval Index, a basket-weighted index, is the market value of a stock portfolio, selected according to participation in the Buenos Aires Stock Exchange, number of transactions and trading value. The index has a base value of US$0.01 as of June 30, 1986. The index is revised every 3 months, taking into account the trading volumes over the past 6 months.
Australia: The S&P/ASX 200 Index	The S&P/ASX 200 measures the performance of the 200 largest index-eligible stocks listed on the ASX by float-adjusted market capitalisation. Representative liquid and tradable, it is widely considered Australia's pre-eminent benchmark index. The index is float-adjusted. The index was launched in April 2000.
Austria: ATX Index	The Austrian Traded Index is a capitalisation-weighted index of the most heavily traded stocks on the Vienna Stock Exchange. The equities use free-float adjusted shares in the index calculation. The index has a base level of 1 000 as of 2 January 1991.
Belgium: BEL 20 Index	The BEL 20 Index is a modified capitalisation-weighted index of the 20 most capitalised and liquid Belgian stocks that are traded on the Brussels Stock Exchange. The equities use free-float shares in the index calculation. The index was developed with a base value of 1 000 as of 1 January 1991.
Brazil: IBOV Index	The Bovespa Index is a gross total return index weighted by traded volume and is comprised of the most liquid stocks traded on the São Paulo Stock Exchange. The Bovespa Index has been divided 10 times by a factor of 10 since 1 January 1985: 2 December 1985, 29 August 1988, 14 April 1989, 12 January 1990, 28 May 1991, 21 January 1992, 26 January 1993, 27 August 1993, 10 February 1994 and 3 March 1997.

Country and index name	Index description and calculation methodology
Canada: S&P/Toronto Stock Exchange Composite Index	The S&P/Toronto Stock Exchange Composite Index is a capitalisation-weighted index designed to measure market activity of stocks listed on the TSX. The index was developed with a base level of 1 000 as of 1975.
Chile: IPSA Index	The IPSA Index is a Total Return Index and is composed of the 40 stocks with the highest average annual trading volume in the Santiago Stock Exchange (Bolsa de Comercio de Santiago). The index has been calculated since 1977 and is revised on a quarterly basis.
Colombia: IGBC Index	The IGBC Index from the Colombia Stock Exchange, also known as the 'General Index', is a liquidity-weighted index of the most liquid stocks traded on the Colombian Stock Exchange (Bolsa de Valores de Colombia). This index has been merged with Medellin and Occidente since 3 July 2001.
Czech Republic: PX Index	The PX Index is the official index of the Prague Stock Exchange. The index was calculated for the first time on 20 March 2006 when it replaced the PX50 and PX-D indices. The index took over the historical values of the PX 50 Index. The PX Index is a price index and dividend yields are not considered in the calculation. The starting date was 5 April 1994 with a base of 1 000 points.
Egypt: EGX 30 Index (CASE)	The EGX 30 Index is a free-float capitalisation-weighted index of the 30 most highly capitalised and liquid stocks traded on the Egyptian Exchange. EGX 30 constituents are reviewed and changed twice a year (February and August). The index was developed with a base level of 1 000 as of 1 January 1998 and previously named the 'CASE 30 Index'.
Finland: OMX Helsinki All-Share Index (HEX)	The OMX Helsinki All-Share Index includes all the shares listed on the Helsinki Stock Exchange. The aim of the index is to reflect the current status and changes in the market. The HEX Index is broken down using the GICS Classification as of 1 July 2005. The index was developed with a base level of 1 000 as of 28 December 1990.

Country and index name	Index description and calculation methodology
France: CAC 40 Index	The CAC 40 Index is a narrow-based, modified capitalisation-weighted index of 40 companies listed on the Paris Bourse. The index was developed with a base level of 1 000 as of 31 December 1987. As of 1 December 2003 the index has become a free-float-weighted index.
Germany: DAX Index	The German Stock Index is a total return index of 30 selected German blue chip stocks traded on the Frankfurt Stock Exchange. The equities use free-float shares in the index calculation. The DAX has a base value of 1 000 as of 31 December 1987. As of 18 June 1999 only XETRA equity prices are used to calculate all DAX indices.
Ghana: GSE Composite Index	All ordinary shares listed on the GSE are included in the index at total market capitalisation, with the exception of those of listed companies that have shares listed on other markets. The index is a market capitalisation-weighted index with base value 1 000 on 31 December 2010.
Greece: ASE Index	The Athens Stock Exchange General Index is a capitalisation-weighted index of Greek stocks listed on the Athens Stock Exchange. The index was developed with a base value of 100 as of 31December 1980.
Hungary: Budapest Stock Exchange Index	The Budapest Stock Exchange Index is a capitalisation-weighted index adjusted for free float. The index tracks the daily price-only performance of large, actively traded shares on the Budapest Stock Exchange. The shares account for 58 per cent of the domestic equity market capitalisation. The index has a base value of 1 000 points as of 2 January 1991 and is a total return index.
India: S&P CNX Nifty Index	The S&P CNX Nifty, a free-float market capitalisation index, is the leading index for large companies on the National Stock Exchange of India. It consists of 50 companies representing 24 sectors of the economy. The base level is defined as 1 000 on 3 November 1995. In January 2005 its level was almost 2000.

Country and index name	Index description and calculation methodology
Indonesia: Jakarta Composite Index	The Jakarta Stock Price Index is a modified capitalisation-weighted index of all stocks listed on the regular board of the Indonesia Stock Exchange. The index was developed with a base index value of 100 as of 10 August 1982.
Ireland: Irish Overall Index	The ISEQ Overall Index is a capitalisation-weighted index of all official list equities on the Irish Stock Exchange but excludes UK-registered companies. The index has a base value of 1 000 as of 4 January 1988.
Israel: TA-100 Index	The Tel Aviv 100 Index is a capitalisation-weighted index of 100 stocks traded on the Tel Aviv Stock Exchange (TASE). The index was developed with a base value of 100 as of 31 December 1991. TA-100 is a total return index.
Italy: FTSE MIS Index	The index will consist of the 40 most liquid and capitalised stocks listed on the Borsa Italiana. In the FTSE MIB Index foreign shares will be eligible for inclusion but not secondary lines. The calculation and methodology will be unchanged from the S&P MIB Index.
Jamaica: Jamaica Stock Exchange (JSE) Market Index	Jamaica Stock Exchange (JSE) Market Index comprises all ordinary companies.
Japan: Nikkei 225 Index	The Nikkei 225 Stock Average is a price-weighted average of 225 top-rated Japanese companies listed in the First Section of the Tokyo Stock Exchange. The Nikkei Stock Average was first published on 16 May 1949, where the average price was ¥176.21 with a divisor of 225.
Latvia: OMXR Index	OMX Riga (OMXR) is an all-share index consisting of all the shares listed on the main and secondary lists on the Riga Stock Exchange in Latvia with the exception of the companies where a single shareholder controls at least 90 per cent of the outstanding shares. The aim of the index is to reflect the current status and changes in the Riga market. Base date is 31 December 1999, with a value of 100.

Country and index name	Index description and calculation methodology
Lithuania: OMX Vilnius (OMXV)	OMX Vilnius (OMXV) is a total return index which includes all the shares listed on the Main & Secondary lists on the Vilnius Stock Exchange. The aim of the index is to reflect the current status &changes on the Vilnius market. Base date is December 31, 1999, with value 100.
Malta: Malta Stock Exchange Index	The Malta Stock Exchange (MSE) Index is a capitalisation-weighted index encompassing all shares traded on the Stock Exchange of Malta. Index = current market value of all shares listed. The index was created on 27 December 1995 with a base value of 1 000. From 19 May 1998 the index has been calculated on a daily basis.
Mauritius: SEMDEX	The SEMDEX Index is a capitalisation-weighted index including all shares traded on the Stock Exchange of Mauritius. Index = current market value of all listed shares/base market value of all listed shares*100 (where the market value of any shares is equal to the number of shares outstanding multiplied by the market value). The base value is adjusted to reflect new listing and rights issues.
Mexico: MEXBOL	The Mexican IPC Index (Indice de Precios y Cotizaciones) is a capitalisation-weighted index of the leading stocks traded on the Mexican Stock Exchange. The index was developed with a base level of .78 as of 30 October 1978.
New Zealand: NZX 50 Index	The New Zealand Exchange Limited 50 Free Float Total Return Index is a modified market capitalisation-weighted index. This index consists of the top 50 companies by free-float-adjusted market capitalisations that are listed on the New Zealand Exchange Limited.
Nigeria: NGSEINDX	The Nigerian Stock Exchange All Share Index was formulated in January 1984 with a base value of 100. Only ordinary shares are included in the computation of the index. The index is value-relative and is computed daily.

Country and index name	Index description and calculation methodology
Norway: OSEAX	Oslo All-Share Index is a market capitalisation-weighted index that tracks the stock performance of all shares listed on the exchange in its respective sectors. The index is classified based on the new GICS system. The index is developed on the base value of 100 as of 29 December 1995.
Poland: WSE WIG 20 Index	The WIG 20 Index is a modified capitalisation-weighted index of 20 Polish stocks that are listed on the main market. The index is the underlying instrument for futures transactions listed on the Warsaw Stock Exchange. The base value was set to 1000 as of 16 April 1994.
Portugal: BVLX Index	The PSI Geral (General) Index is the all-share market index, including all the shares listed on the Main Market, with the exception of non-voting preferred shares. The index reproduces the total return of the main Portuguese market. Then index base value is 1 000, as of 5 January 1988.
Russia: MICEX Index	The MICEX Index is the real-time cap-weighted Russian composite index. It comprises the 30 most liquid stocks of the largest and most developed Russian companies from 10 main economic sectors. The MICEX Index was launched on 22 September 1997, base value is 100. The MICEX Index is calculated and disseminated by the MICEX Stock Exchange; the main Russian stock exchange.
Singapore: FTSE Straits Times Index	The revamped Straits Times Index, calculated and disseminated by FTSE, comprises the top 30 SGX Main Board-listed companies on the Singapore Exchange selected by full market capitalisation. The index was revamped effective 10 January 2008.
Spain: IBEX 35 Index	The IBEX 35 is the official index of the Spanish Continuous Market. The index is comprised of the 35 most liquid stocks traded on the continuous market. It is calculated, supervised and published by the Sociedad de Bolsas. The equities use free-float shares in the index calculation. The index was created with a base level of 3 000 as of 29 December 1989.

Country and index name	Index description and calculation methodology
South Africa: JALSH Index	The FTSE/JSE Africa All Shares Index is a market capitalisation-weighted index. Companies included in this index make up the top 99 per cent of the total pre-free-float market capitalisation of all listed companies on the Johannesburg Stock Exchange.
Sweden: OMX 30 Index	The OMX Stockholm 30 Index is a capitalisation-weighted index of the 30 stocks that have the largest volume of the trading on the Stockholm Stock Exchange. The equities use free-float shares in the index calculation. The index was developed with a base level of 125 as of September 30, 1986. ** Effective on 27 April 1998 there was a 4–1 split of the index value.
Switzerland: Swiss Market Index	The Swiss Market Index is a capitalisation-weighted index of the 20 largest and most liquid stocks of the SPI universe. It represents about 85 per cent of the free-float market capitalisation of the Swiss equity market. The SMI was developed with a base value of 1 500 as of 30 June 1988.
Trinidad and Tobago: TT COMP Index	The Trinidad and Tobago Composite Index is a market cap-weighted index of all the First Tier Ordinary stocks traded on the Trinidad and Tobago Stock Exchange. The exchange started trading full time on 1 April 2008.
Turkey: ISE National 100 Index	The Istanbul Stock Exchange National 100 Index is a capitalisation-weighted index composed of National Market companies except investment trusts. The constituents of the ISE National 100 Index are selected on the basis of pre-determined criteria directed for the companies to be included in the indices. The base date is January 1986 and base value is 1 for the TL-based price index.
USA: S&P 500 Index	Standard and Poor's 500 Index is a capitalisation-weighted index of 500 stocks. The index is designed to measure performance of the broad domestic economy through changes in the aggregate market value of 500 stocks representing all major industries. The index was developed with a base level of 10 for the 1941–43 base period.

Country and index name	Index description and calculation methodology
United Kingdom: FTSE 100 Index	The FTSE 100 Index is a capitalisation-weighted index of the 100 most highly capitalised companies traded on the London Stock Exchange. The equities use an investibility weighting in the index calculation. The index was developed with a base level of 1 000 as of 3 January 1984.